Chapter Nine

Central Nervous System

In the last chapter, you learned how nerve cells (aka-neurons) are the most basic structure within the nervous system. This week, we are going to bundle up large numbers of these neurons and follow the path of their impulses towards the control center of the body in a little place we call the...

Central Nervous System (CNS)

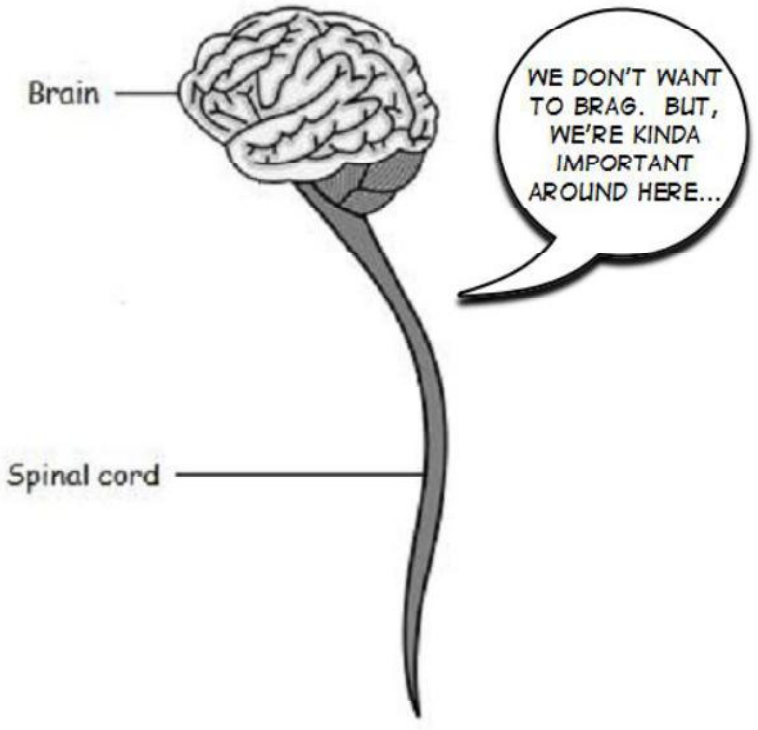
The central nervous system lies in the center (go figure) of every nerve impulse throughout our bodies and contains only two different organs:

The Brain and Spinal Cord

Before we explore these amazing organs, let's go through a little review...

The main functions of the nervous system are to receive signals concerning what is going on inside and outside our bodies (perception); to sort and direct these signals to other areas of the body (integration); and, to manage the responses of the organ systems to these signals.

Neurons send nerve impulses from the sensory receivers throughout our bodies (like the skin, eyes, tongue, etc.) toward the organs of the CNS. Once received, these organs react by sending new impulses to the effectors (muscles or glands) that allow us to react to a stimulus. The nerves that send signals towards the CNS are known as sensory (afferent) nerves while those which carry the response impulses are called motor (efferent) nerves.



Let's look at how the body protects its control center!

To begin with, brain and spinal cord are two organs which are attached to each other and are protected by specialized bones. The **skull** surrounds the brain and the *vertebral column* protects the spinal cord. Both of these skeletal protectors are made up of a number of individual layers of tissues. The most important of these tissues are known as the **meninges**. The meninges are the three innermost fiber-like layers of tissue that cradles the brain and spinal cord within the skull and vertebral column. The space between the meninges and the organs is filled with a specialized fluid known as **cerebrospinal fluid** or **CSF**. This fluid helps to support the brain and spinal cord by allowing it to "float" within their bony protectors.

Think of it like this...

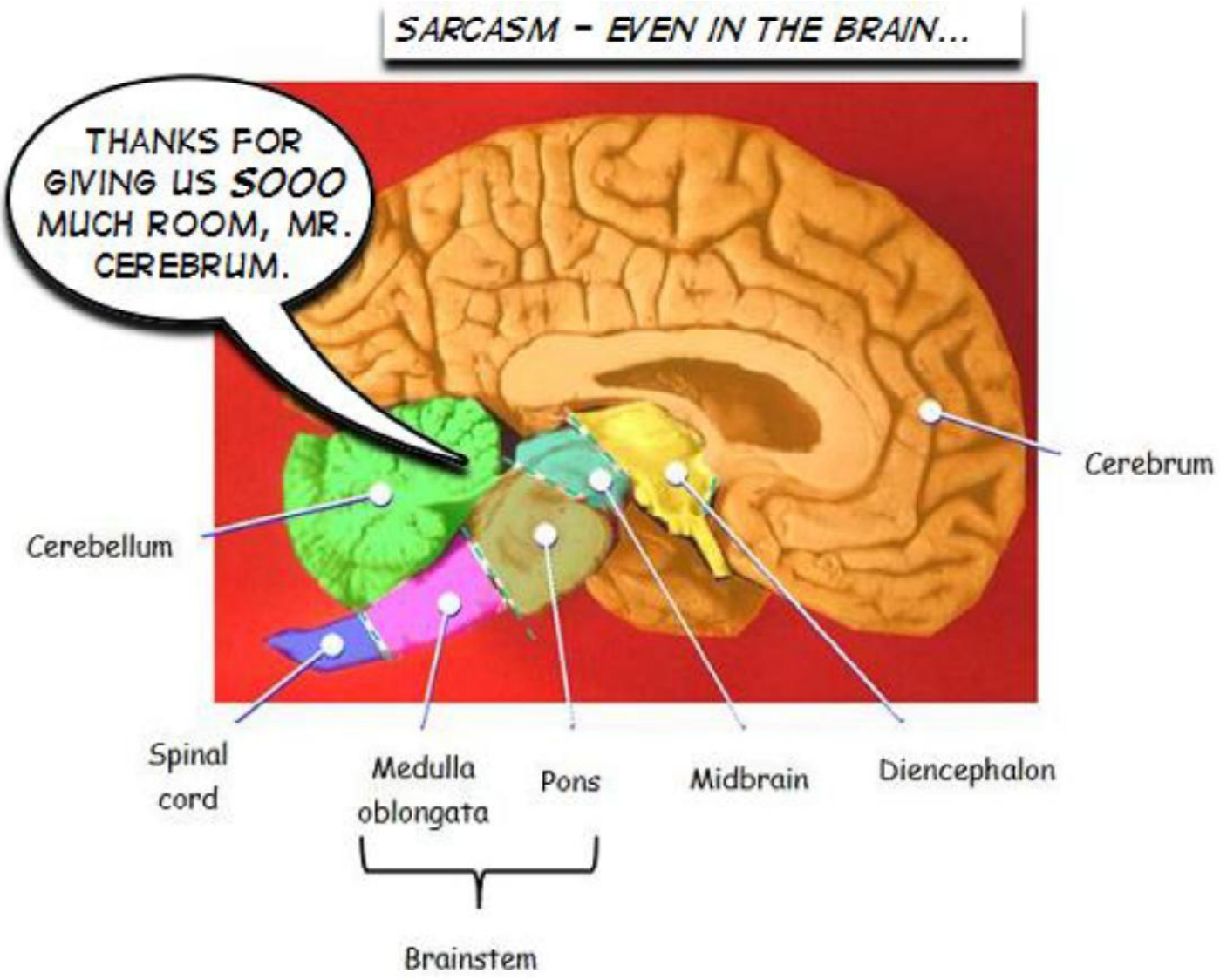
The brain is like a person driving a car. If the car hits a wall, the car will stop immediately; however, the driver will continue moving forward and will hit the steering wheel very fast unless he is wearing a seat belt. Without the seat belt, the driver may suffer a serious injury.

The tough, fibrous layers of the meninges act like seat belts which hold the brain in position. The CNS would be the bumper of the car which cushions the brain from sudden bumps as well.

Now that you know how the body protects the CNS, let's take a closer look at each of these two amazing organs. Our first stop... the brain!

The **brain** is one of the largest organs in the human body with an average weight of 3 pounds (1.36 kg) and contains roughly 100 billion neurons. There are six major areas of the brain which we will now explore:

Medulla oblongata, Cerebellum, Cerebrum, Diencephalon, Midbrain, and the Pons



Medulla oblongata

The **medulla oblongata** connects the spinal cord to the brain and is responsible for nearly all of the main functions within the cardiac, respiratory, and digestive systems. In many instances, nerve impulses will travel from the body into the spinal cord and upward into the brain through sensory/afferent nerves. Once the brain has processed the signal, it sends a nerve impulse back into the spinal column through motor/efferent nerves. Two large bundles of these afferent and efferent nerves can easily be seen within the medulla oblongata and are known as **the pyramids**. Many of these nerves cross from one pyramid to another as nerve impulses travel to and from the CNS. The crossing of nerves between the pyramids is the main reason why the right side of the brain controls the left side of the body and vice versa.

Pons

The **pons** (a Latin word meaning "bridge") does exactly as its name implies. It connects the various areas of the brain into one single area. The pons is located above the medulla oblongata and anterior to the cerebellum.

In addition to acting as a bridge, the pons also relays information from the medulla oblongata to other areas of the brain and is responsible for several functions of the respiratory system. Together, the pons and medulla oblongata are known as the **brainstem**.

Midbrain

The midbrain is located between the pons and the diencephalon and is typically classified as a portion of the brainstem. This area of the brain is associated with the sensations of motor control, sleep/wake cycles, and alertness. In addition, it also serves as a relay station for the sensations of vision and hearing.

Cerebellum

The **cerebellum** also is known as the "little brain" or "small brain." Despite its name, this section is the second-largest area of the brain. The cerebellum is located in the posterior area of the brain, just above the brainstem. Inside its structure, the cerebellum resembles a tree called the **arbor vitae**, or "tree of life."

It is the cerebellum you can thank for the coordination of your movements, including your balance, equilibrium, and posture.

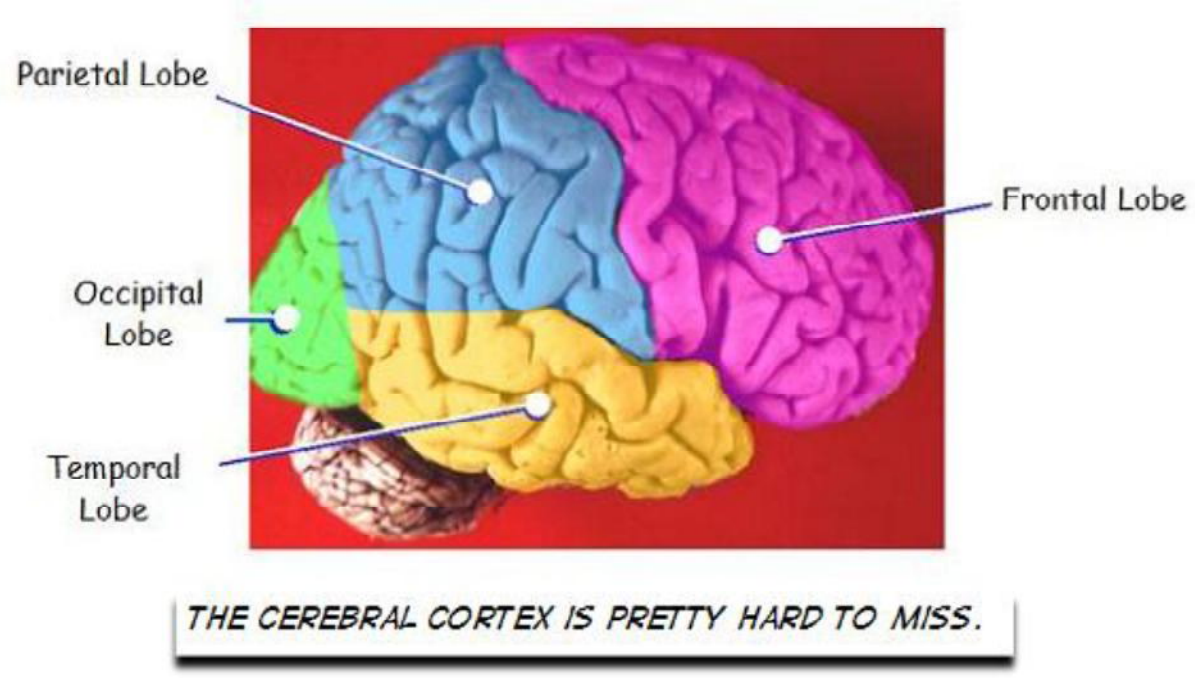
Cerebrum

The **cerebrum** is often called the "true brain" and makes up the majority of the brain's mass. If I were to ask you to close your eyes and imagine what a brain looks like, you would likely think about a wrinkly mass of tissue that contains a thin valley through its center separating it into two sections. Right? Both of these sections are known as the **right and left cerebral hemispheres**. The "wrinkly mass" you can picture in your mind is a thin layer of tissue known as the **cerebral cortex.**

Each hemisphere has a set of controls for sensory and motor activities of the body which eventually pass through the pyramids. Due to the neural "wiring" within the pyramids, the right hemisphere of the brain controls the left side of the body and vice versa. In addition, the upper areas of the cerebral cortex control the lower body activities while the lower areas of the cortex control upper-body activities as well! Cool, huh?

The cerebral cortex is divided into areas (**lobes**) each responsible for specific functions in the body:

Name of lobe	Location in brain	Function of lobe
Frontal lobe	Anterior section	Intelligence, memory, and idea association
Parietal lobe	Upper middle section	Sensations of temperature, touch, and sense of position and movement as well as the perception of size, shape, and weight
Temporal lobe	Lower middle section	Responsible for the perception of hearing
Occipital lobe	Posterior area	Responsible for the perception of vision



Diencephalon

The **diencephalon** is a region between the midbrain and the cerebrum. This area of the brain can be broken down into separate structures as well, the most important of which being the **thalamus** and *hypothalamus*. The thalmus acts as a processing center for most of the sensory information received by the brain. Nerve impulses traveling through the thalamus are typically directed to specific areas of the brain that are prepared to respond to specific stimuli. The hypothalamus, as you learned back in Chapter 3, is also a vital area as it has the important jobs of regulating body temperature, water balance, sleep-wake cycles, hunger, satiation, emotions, and many of the chemical messengers which move throughout our body.

Now that you have a good idea about our brain, let's take a look at the second organ of the CNS - the spinal cord!

The **spinal cord** looks like a long oval-shaped cylinder about 0.5 inches (1.3 centimeters) in diameter with two deep grooves running down its length and is found in openings in the bones within the vertebral column. It extends from the medulla oblongata downward through the vertebrae for approximately 16 to 18 inches (42 to 45 centimeters). As stated above, the cord is surrounded and protected by the three-layered meninges which are filled with cerebrospinal fluid.

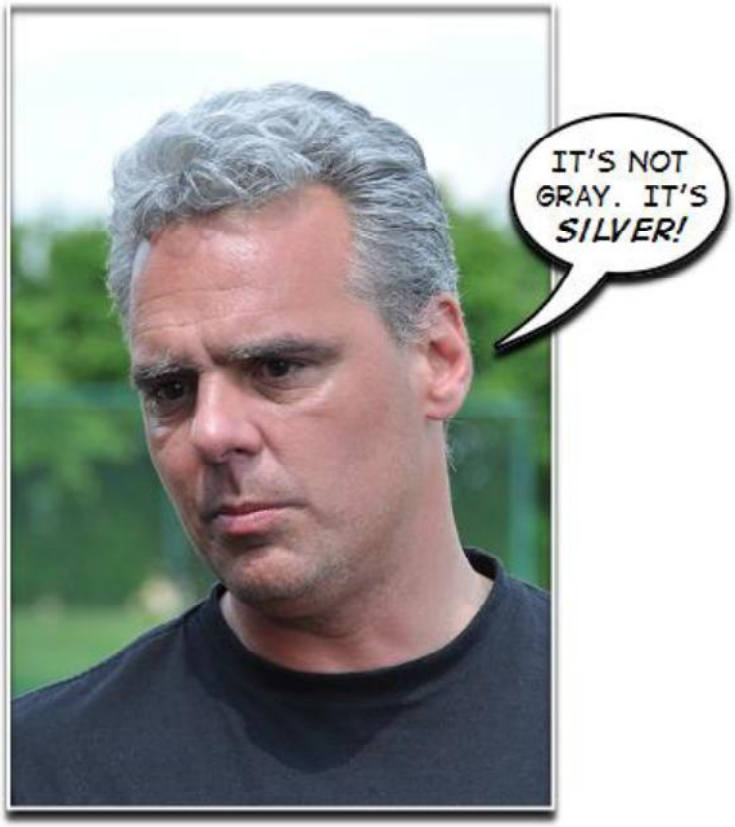
You might be thinking that the length of the spinal cord is a little small compared to your spinal column.

As your body is developing, bone tissue grows much faster than nerve tissue. Therefore, the bones of the vertebrae column extend far beyond the length of the cord itself. Typically, the cord only reaches close to where the last ribs are attached to the spine. But it doesn't end there!

The spinal cord continues to extend down the vertebrae column as a series of thin nerves resembling the shape of a horse's tail. Because of this shape, this collection of nerves is known as **cauda equina** which is Latin for "horse's tail."

What makes up the spinal cord?

Two types of solid material make up the inside of the spinal cord (and the brain as well): **gray matter** and **white matter**. Gray matter consists of unmyelinated neurons which are grayish in color. Due to the lack of myelin, the neurons which make up the gray matter carry the slowest nerve impulses in the brain. The white matter (yes... it really does look white due to the presence of the white-colored myelin) consists of thousands of myelinated nerve fibers that send nerve impulses up and down the spinal cord. It is the afferent nerves within the white matter that carries the primary nerve impulses to the brain and the efferent nerves of white matter which carry impulses away from the brain.



How does the brain communicate with the spinal cord and the rest of the body?

This is bit of a gray area (no pun intended) because of the number of nerve impulses that exist in our bodies. The nerves, spinal cord, and brain work together to keep you aware of what is going on inside and outside of your body.

However, not all nerve impulses reach the brain. Some are managed solely by the spinal cord itself. For example, your spinal cord makes you drop a frying pan you didn't realize was very hot until it was too late. Before the nerve impulses reach your brain and you become aware of the pain, you've already released the pan!

Other times, nerve impulses remain entirely within the brain. Our eyes, for example, are attached to *optic nerves* which are connected directly to the brain. This helps us to react quickly to stimuli we sense in our environment by bypassing the spinal cord.

And in some occasions, the CNS is completely taken out of the process. Our hearts, for example, do not require our spinal cord or brain to instruct it to beat. As you learned back in Chapter 2, the function of cardiac muscle tissue is involuntary and operates without the use of the brain or spinal cord.

Where do we go from here?

Well, there are thirty-one pairs of **spinal nerves** which are attached to the sides of the spinal cord and 12 pairs of **cranial nerves** attached to the brain which eventually spread out throughout our bodies. Remember, all of these nerve impulses have to get to and from the CNS. Therefore, all of these nerves will be the focus of our study next week as we explore...

the Peripheral Nervous System

Match the following vocabulary terms with their correct definition:

arbor vitae	**frontal lobe**	**occipital lobe**
brain	**gray matter**	**parietal lobe**
cauda equina	**lobes**	**the pyramids**
cerebellum	**medulla oblongata**	**skull**
cerebral cortex	**meninges**	**spinal cord**
cerebrospinal fluid	**pons**	**temporal lobe**
cerebrum	**cerebral hemispheres**	**white matter**
cranial nerves	**spinal nerves**	
diencephalon	**thalamus**	

1)	_____	12 pairs of nerves attached to the brain which spread throughout the body
2)	_____	31 pairs which are attached to the sides of the spinal cord
3)	_____	a large bundle of nerve fibers protected within the vertebral column
4)	_____	a relay and processing center for most sensory information received into the brain
5)	_____	a specialized fluid located in the space between the meninges and the organs
6)	_____	area of the brain which connects the spinal cord to the brain
7)	_____	collection of fused irregular bones which protect the brain
8)	_____	connects the various areas of the brain into one single organ; located above the medula oblongata, below the midbrain and anterior to the cerebellum

9)	_____	extension of thin nerves below the vertebrate column resembling the shape of horse's tail
10)	_____	lobe of the cerebral cortex which is responsible for intelligence, memory, and idea association
11)	_____	lobe of the cerebral cortex which is responsible for sensations of temperature, touch, and sense of position and movement as well as the perception of size, shape, and weight
12)	_____	lobe of the cerebral cortex which is responsible for the perception of hearing
13)	_____	lobe of the cerebral cortex which is responsible for the perception of vision
14)	_____	makes up the majority of the brain's mass; separated into right and left hemispheres
15)	_____	neurons and unmyelinated dendrites and axons and is grayish in color within the brain
16)	_____	one of two main organs of the CNS; control center for most neural activity throughout the body
17)	_____	region between the midbrain and the cerebrum; contains the thalamus and hypothalamus
18)	_____	second-largest area of the brain; found above the medulla oblongata; responsible for movements, balance, equilibrium, and posture
19)	_____	specialized areas of the cerebral cortex which is responsible for specific functions in the body
20)	_____	thousands of myelinated nerve fibers that send nerve impulses up and down the cord

21)	_____	three fiber-like layers of tissue that cradles the brain and spinal cord within the skull and vertebral column
22)	_____	tree of life; name given to the anatomy of the cerebellum
23)	_____	two halves of the cerebrum
24)	_____	two large bundles of afferent and efferent nerves within the medulla oblongata; responsible for right/left sides of the brain controlling opposite sides of the body
25)	_____	wrinkly mass surrounding the right/left cerebral hemispheres

Choose the correct answer from the following questions:

1) **Control of temperature, emotions, hunger, and thirst are functions associated with the:**
   A) thalamus
   B) cerebellum
   C) hypothalamus
   D) medulla oblongata
   E) cerebrum

2) **White matters refers to:**
   A) unmyelinated neurons within the spinal cord
   B) unmyelinated neurons within the CNS
   C) unmyelinated neurons within the brain
   D) myelinated neurons within the CNS
   E) myelinated neurons within the brain

3) **The medulla oblongata is also known as the:**
   A) diencephalon
   B) brain stem
   C) pineal gland
   D) hypothalamus
   E) cerebellum

4) **The term "central nervous system" refers to the:**
   A) spinal cord and afferent nerves
   B) autonomic and efferent nerves
   C) brain, spinal cord, and efferent nerves
   D) brain and afferent nerves
   E) brain and spinal cord

5) The inability to remain balanced can result from damage to the:

A) hypothalamus
B) cerebrum
C) midbrain
D) cerebellum
E) thalamus

6) Lobe that is responsible for your ability to determine the weight of an object:

A) frontal lobe
B) occipital lobe
C) parietal lobe
D) temporal lobe

Application Question:

Cerebral meningitis is a condition in which the meninges of the brain become inflamed as the result of viral or bacterial infection. Do you believe this condition can be life threatening? Why or why not?